

High-Current HTS Cables for Fusion: Development Status and Prospects

Luigi Muzzi

Superconductivity Laboratory – ENEA, Italy

E-mail: luigi.muzzi@enea.it

Abstract—Research and development activities on nuclear fusion have grown rapidly worldwide in the last few years, with an increasing number of experimental reactors being designed or constructed with the aim to demonstrate the scientific and technological feasibility of fusion as a viable energy source. Magnetic confinement fusion, based on the use of superconducting magnets to confine, heat and control the plasma, is one of the approaches being pursued. In particular, High-Temperature Superconducting (HTS) technologies have been identified as one of the key enablers for the achievement of commercial fusion plants, either integrating Low-Temperature Superconducting (LTS) technologies to improve performance, or completely substituting them, thus accessing different operating temperature / field ranges and proposing alternative approaches to magnet technology.

This has boosted enormously the development of HTS, Rare-Earth-Barium-Copper Oxide (REBCO) coated conductors, in terms of superconducting performance and, above all, industrial production capabilities and maturity. In parallel, a lot of effort has been spent in the R&D on multi-tape, high-current conductors, operating in the tens of kA range and up to about 20 T field, as a fundamental building block for the required high-performance magnets. A few concepts and layouts have been proposed, to assemble the large number of tapes required for high-current conductors, into structures that can be manufactured at industrial scale, and that can provide satisfactory performance, also with repeated electromagnetic loading cycles.

After recalling the main challenges and development steps undertaken on large size, high-current LTS Cable-in-Conduit Conductors for fusion, the state-of-the-art of HTS-based ones will be illustrated and commented, with respect to the typical requirements for fusion coils, adapted to the specific features and operating regimes of HTS technologies. The main challenges toward the achievement of a truly mature and robust technology for high-current HTS conductors will be illustrated, along with the on-going or planned experimental activities to address them.

Keywords (Index Terms)—Cable-in-Conduit-Conductor (CICC), Fusion Magnets, High Temperature Superconductor (HTS) coated conductors

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 63, Mar. 2026.
Presentation given at ISS 2025, Nagasaki, Japan, Dec. 2025.